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Health and Environmental Effects
Profile for Propachlor

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16. ABSTRACT The Health and Environmental Effects Profile for <u>Propachlor</u> was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents. Quantitative estimates have been presented provided sufficient data are available. <u>Propachlor</u> has been determined to be a systemic toxicant. An Acceptable Daily Intake (ADI), defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect, for <u>Propachlor</u> is 1.3×10^{-2} (mg/kg bw/day) for oral exposure.			
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FOR PROPACHLOR

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PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEP's are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched."

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEP's will become part of the EPA RCRA docket.

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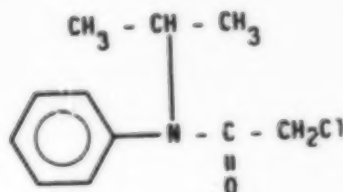
LIST OF ABBREVIATIONS

ADI	Acceptable daily intake
a.i./ha	Active ingredient/hectare
BCF	Bioconcentration factor
gal/acre	Gallons per acre
GI	Gastrointestinal
ID ₅₀	Dose inhibitive to 50% of recipients
i.v.	Intravenous
kph	Kilometers per hour
LC ₅₀	Concentration lethal to 50% of recipients
LD ₅₀	Dose lethal to 50% of recipients
ppb	Parts per billion
ppm	Parts per million
TLC	Thin layer chromatography
UV	Ultraviolet

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

Propachlor is the common name for 2-chloro-N-isopropylacetanilide. Current Chemical Abstract usage is 2-chloro-N-(1-methylethyl)-N-phenylacetamide. Other chemical synonyms include 2-chloro-N-isopropyl-N-phenylacetamide, alpha-chloro-N-isopropylacetanilide and N-isopropyl-2-chloroacetanilide. In 1965, propachlor was introduced as a herbicide by the Monsanto Company under the code number CP 31393 and the trade mark Ramrod (BCPC, 1977). Other trade names for propachlor include Bexton (Dow Chemical Co.), Niticid and Satecid. The structural and molecular formulae for propachlor are as follows:



The molecular formula for propachlor is $C_{11}H_{14}ClNO$ and the molecular weight is 211.71. The Chemical Abstract Service (CAS) registry number is 1918-16-7.

1.2. PHYSICAL AND CHEMICAL PROPERTIES

Propachlor is a light tan solid compound. Selected physical properties are listed below (WSSA, 1979; BCPC, 1977 unless otherwise noted):

Density:	1.13 g/ml at 25°C
Melting point:	77°C
Boiling point:	110°C at 0.03 mm Hg
Decomposition temperature:	170°C

Vapor pressure:

<u>Temperature °C</u>	<u>mm Hg</u>
20	4×10^{-4} (Ouellette and King, 1977)
25	2.3×10^{-4}
110	3×10^{-2}

Water solubility:

580 ppm at 20°C
700 ppm at 20°C (Ouellette and King, 1977)
613 µg/mL at 24°C (Beestman and Deming, 1974)

Log octanol/water partition coefficient

1.61 (Rao and Davidson, 1982)

Propachlor is readily soluble in most organic solvents except aliphatic hydrocarbons. It has good relative resistance to decomposition by UV irradiation (WSSA, 1979; BCPC, 1977).

1.3. PRODUCTION DATA

Propachlor is prepared by the reaction of chloroacetyl chloride and N-isopropylaniline (BCPC, 1977).

The domestic producers of propachlor are Monsanto Co. in Muscatine, IA, and Dow Chemical in Midland, MI (USITC, 1983; SRI, 1983). Current production figures are not available. In 1971, a reported 23 million pounds were produced (Ouellette and King, 1977).

1.4. USE DATA

Propachlor is a pre-emergence herbicide effective against annual grasses and certain broadleaved weeds in corn (all types), cotton, soybeans, sugar cane, peanuts, sorghum and several vegetable crops, including Brassicas, onions, peas and beans (BCPC, 1977; WSSA, 1979). The rates of applications are normally 3-6 lb/A broadcast or 3.5-5 kg a.i./ha. The usual carriers are granular formulations in attapulgite/montmorillonite clay, wettable powder and liquid flowable in 20-40 gal/acre of water broadcast.

In 1975, domestic consumption of propachlor was reportedly 10.9 million pounds, of which 9.4 million pounds were used in corn, 1.4 million pounds in grain sorghum and 0.1 million pounds in soybeans (SRI, 1976). In 1976, American farmers used 11 million pounds of propachlor: 7.73 million pounds for corn, 3.13 million pounds for sorghum and 0.16 million pounds for soybeans (Eichers et al., 1978). In 1982, domestic consumption decreased to 7.8 million pounds: 3.5 million pounds for corn and 4.3 million pounds for grain soybean (U.S. Dept. Agriculture, 1983).

2. ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

2.1. WATER

The photolysis of propachlor in aqueous solution has been studied by Tanaka et al. (1981) under laboratory conditions. A 10 ml sample of propachlor in water at a concentration of 100 ppm was irradiated for 135 minutes with a 300-nm sunlight lamp. Only 1% of the propachlor was lost. Addition of a commercial surfactant (added to simulate a pesticide formulation that included surfactants) to act as a photosensitizer allowed 37% of the propachlor to be lost during the photolysis test. However, since the intensity of the irradiation source was not given, a direct extrapolation to the environment cannot be made.

The possibility of the hydrolysis of propachlor in aquatic media has not been comprehensively studied. The chemical structure of propachlor suggests that the chlorine atom may be subject to hydrolysis reactions in the environment. WSSA (1979) reported that the chemical breakdown of propachlor in soil accounts for ~6% of its loss, as compared with 94% loss from microbial breakdown. Therefore, hydrolysis of propachlor in the aquatic environment may be of significance but is of secondary importance compared with microbial degradation.

The rate of biodegradation of propachlor in natural aquatic media is not known. Based on the ability of soil microorganisms to degrade propachlor (see Section 2.3.), it can be speculated that biodegradation of this compound in aquatic media will take place and that the loss of propachlor from biodegradation may be significant.

The extremely low vapor pressure of propachlor (Section 1.2.) suggests volatilization is of limited significance. However, the volatility of propachlor from soils has been measured under laboratory conditions, as

noted in Section 2.3., by Beestman and Deming (1974, 1976). The half-life of propachlor in continuously moist soils was 4.5 days (silt soil) and 18.5 days (clay loam soil), while in dry soils the half-lives were 94 days (silt soil) and 189 days (clay loam soil). Although this would appear to suggest that volatilization of propachlor from aquatic media may occur, other variables (i.e., microbial breakdown and hydrolysis) probably account for the observed differences.

The loss of propachlor by sorption and subsequent sedimentation in water bodies has not been studied in detail. Ritter et al. (1974) measured the amount of propachlor lost to surface runoff and sediments from four watersheds in Iowa. Runoff from a storm measured 0.116 lb/A loss in water and 0.039 lb/A loss in sediment 8 days after application; 25 days after application, runoff from a storm measured 0.017 lb/A loss in water and no loss in sediment. In terms of soil adsorption, propachlor is neither tightly bound nor highly mobile (see Section 2.3.); although WSSA (1979) reports that propachlor is adsorbed by soil colloids. The loss of propachlor by sorption and sedimentation in water bodies does not appear to be very significant.

Kenaga (1980) has predicted the BCFs for propachlor to be 17 and 14, based on water solubility and organic carbon content, respectively. BCF values of <100 indicate a low potential for bioconcentration. The log octanol-water partition coefficient for propachlor, 1.61 (Rao and Davidson, 1982), also predicts that propachlor will not be strongly bioconcentrated. Yu et al. (1975) studied propachlor in a model ecosystem; after a 33-day experimental period, no propachlor was detected in any organism, including algae, clam, daphnia, elodea, fish, mosquito or snail.

The overall persistence of propachlor in the aquatic media has not been studied extensively. In the model ecosystem as studied by Yu et al. (1975), only 0.4% of the initial concentration of propachlor remained after 33 days.

Yu et al. (1975) concluded that propachlor appears to be labile in the aquatic environment. It should be emphasized that in the natural environment the persistence of propachlor will vary, depending on the characteristics of the water body.

2.2. AIR

Specific data regarding the fate or transport of propachlor in the atmosphere were not located in the available literature. The sparse photolysis data discussed in Section 2.1. would indicate that rapid photodecomposition of propachlor in the atmosphere is not expected. In addition, Beestman and Deming (1974) reported that unpublished data obtained from Monsanto show that propachlor has no UV absorption above 280 nm, indicating little environmental photolysis. It has been suggested by Cupitt (1980) that adsorption will be a reasonable vapor-phase removal mechanism only for chemicals with saturation vapor pressures of 10^{-7} mm Hg or less. Since the vapor pressure of propachlor at 20°C is on the order of 10^{-4} mm Hg, sorption in the air is unlikely.

2.3. SOIL

The fate and transport of propachlor in soil have been more adequately studied than its fate and transport in atmospheric and aquatic media. The chemical processes that have been reported to cause the disappearance of propachlor from soils are microbial breakdown, 94%, and chemical breakdown, 6% (WSSA, 1979).

Under laboratory conditions, Beestman and Deming (1974) determined that dissipation of propachlor from sterilized soil was 50 times slower than dissipation from viable soil, indicating that microbial degradation plays a major role in the degradation of propachlor in soils. Kaufman and Blake (1972) identified the following microorganisms that are capable of degrading

propachlor: Aspergillus ustus, Fusarium oxysporum, Fusarium solan, Pencil-
lium janthinellum and Trichoderma viride. Other investigators have also
shown that propachlor undergoes microbial degradation (Kaufman and Edwards,
1993; Kaufman et al., 1971; Lee et al., 1982; Rankov and Velez, 1976).

Kaufman et al. (1971) reported that dehalogenation of propachlor to
hydroxypropachlor is a mechanism of microbial degradation. Lee et al.
(1982) identified the following metabolites of propachlor degradation:
N-isopropylaniline, N-isopropylacetanilide, N-(1-hydroxy-isopropyl) acetani-
lide and N-isopropyl-2-acetoxyacetanilide.

WSSA (1979) reported that the loss of propachlor from, in or on soils is
negligible with respect to photodecomposition. Beestman and Deming (1974)
also suggested that photodecomposition of soil-applied propachlor would not
be expected to be significant, as the UV absorption spectrum reveals no
absorption above 280 nm.

Beestman and Deming (1974, 1976) studied the volatilization of propa-
chlor from soils under laboratory conditions. Volatilization rates were
determined from dry soils and from continuously wet soils held in a constant
3.2 kph, 21°C laminar air stream. The volatilization half-lives of propa-
chlor in continuously wet soils were 4.5 days (silt soil) and 18.5 days
(clay loam soil), while in dry soils the half-lives were 94 days (silt soil)
and 189 days (clay loam soil). According to Beestman and Deming (1974), the
volatilization rates determined for continuously wet soils would occur in
the field only during that interval when soil was directly exposed to windy
conditions and remained very moist. The natural tendency of surface soil in
the environment to dry would greatly diminish the volatilization of propa-
chlor. Under the laboratory test conditions, propachlor volatilization from

wet soils exhibited an initial rapid rate followed by a first order kinetic rate; this was followed by a slower first order kinetic rate that reflected the process of adsorption/desorption and herbicide movement with the water toward the soil surface by capillary action and eventual loss to the atmosphere.

The leachability of propachlor in soils is expected to be inversely related to its adsorption. The mobility of propachlor in soil was determined by Helling and Dragun (1981) by means of soil TLC and soil column leaching experiments. They determined that propachlor has an intermediate mobility in both silty clay loam and clay loam soils (R_f values of 0.63 and 0.47, respectively). Beestman and Deming (1974) measured the leaching of propachlor under field conditions in Missouri (Ray silt and Wabash silty clay soils), and found, despite moist field conditions, that <1% of the applied propachlor could be detected below the upper 4-cm depth level. Ritter et al. (1974) measured the leaching of propachlor as part of a watershed runoff study in Iowa; in both ridged watershed and surface-contoured watersheds, very little propachlor moved below the 3-inch depth. In an abstract of a foreign study, Nesterova et al. (1980) noted that under abundant rainfall, propachlor and other herbicides were detected in the 0-30 cm soil layer after being washed downward. Weber and Best (1972) measured the relative mobility of propachlor (as compared with 12 other herbicides) in the field by movement over the soil surface into adjacent control areas; they found propachlor to have an intermediate mobility.

The transport of propachlor in runoff has been studied (Baker and Laflen, 1979; Ritter et al., 1974). Baker and Laflen (1979) measured the loss of propachlor in water and sediment from small field plots by means of a simulated rainfall within a few hours of application. Propachlor losses to plots using surface application averaged 3%; corresponding losses from

plots in which the propachlor was incorporated by disking was 0.8%. Data from Ritter et al. (1974) are presented in Section 3.1.

The persistence of propachlor in soil as a result of all the microbial, chemical and physical processes has been studied by several authors. Zimdahl and Clark (1982) measured the half-life of propachlor in clay loam and sandy loam soils in the laboratory, utilizing various temperature and moisture conditions. An increase in both temperature (10-30°C) and moisture content (20-80% of field capacity) lowered the half-life. For example, at 20°C and a soil moisture content of 20, 50 and 80%, the half-lives in clay loam were 21.5, 5.3 and 4.1 days, respectively. At a 50% moisture content and temperatures of 10, 20 and 30°C, the half-lives in clay loam were 14.3, 5.3 and 1.0 days, respectively. Similar half-lives were measured for sandy loam. Beestman and Deming (1974) measured the half-life of propachlor under warm, moist field conditions in Missouri Ray silt and Wabash silty clay; the determined half-lives were 1.9 days in silt and 4.4 days in silty clay. Ritter et al. (1974) measured the soil profile for applied propachlor in an Iowa runoff study and noted that only 29-30% of the propachlor remained after 21 days in ridged and surface-contoured watersheds. Vasil'ev (1982) reported that propachlor applied at 4-8 kg/ha was detoxified in peat soil within 59-63 days, in rutabaga root crop within 78-82 days and in haulms within 68-72 days in a wet year; degradation was delayed in a dry year. Zhukova and Shirko (1979) reported that 50 days after application of propachlor (10 kg/ha) to soil, only 12% remained. In terms of degradation rate in soil, Doyle et al. (1978) found that sewage sludge retards degradation of propachlor, while dairy manure increases the degradation rate. WSSA (1979) reported that the resultant average persistence of propachlor in soils of recommended rates is 4-6 weeks, but longer in soils high in organic matter.

3. EXPOSURE

3.1. WATER

Ritter et al. (1974) monitored the amount of propachlor in runoff water and sediment for surface-contoured and ridged watersheds at an experimental farm in Castana, IA for the period 1967-1970; rates of application were 3-4 lb/A. No runoff occurred in 1968 and 1969 before the propachlor had degraded. In 1967, samples of runoff were collected 14 days after application and no detectable levels of propachlor were observed in the water or sediments. After a storm in 1970, 8 days after application, 0.155 lb/A of propachlor was in the runoff water and sediment from the surface-contoured watershed. This is equal to a concentration of 1702 ppb (Wauchope and Leonard, 1980).

The U.S. EPA STORET Data Base reports the analysis of propachlor in 548 water samples. The mean concentration of propachlor in the samples was reported to be 0.296 $\mu\text{g/L}$, with a range of concentrations of 0.02-8.6 $\mu\text{g/L}$.

No data on the occurrence of propachlor in drinking water were located in the available literature.

3.2. FOOD

The National Soils Monitoring Program has been conducted by the U.S. EPA. For the fiscal year 1970, soil and crop residues of pesticides were monitored for 1506 cropland sites in 35 states (Crockett et al., 1974). As a residue in crops, propachlor (Ramrod) was detected at only one site (in soybeans at one of 178 soybean monitoring sites), at a concentration of <0.01 ppm. Monitoring in subsequent years, during the National Soils Monitoring Program, detected no residues of propachlor in crops (Carey et al., 1978, 1979).

Frank et al. (1977) and Shirko and Kharitonova (1981) applied propachlor to onion fields and then monitored the onions at harvesting time for propachlor residues. No residues of propachlor were detected at the time of harvest.

WSSA (1979) reported that propachlor is absorbed mainly by germinating seedling shoots, secondarily by roots in plants. It is translocated throughout the plant, with higher concentrations in vegetative parts than in reproductive parts. Metabolism in the plant is almost complete within 5 days.

3.3. INHALATION

Monitoring data for propachlor exposure in the air could not be located in the available literature.

3.4. DERMAL

Monitoring data for propachlor exposure on the skin could not be located in the available literature.

4. PHARMACOKINETICS

4.1. ABSORPTION

No studies examining the absorption of propachlor were found in the available literature; however, it can be inferred from metabolism (Section 4.3.) and excretion (Section 4.4.) studies in rats that propachlor and its metabolites are absorbed from the GI tract of rats following oral administration. Further details regarding actual plasma levels or the kinetics of absorption were not available.

4.2. DISTRIBUTION

Pertinent data regarding the distribution of propachlor could not be located in the available literature.

4.3. METABOLISM

The metabolism of propachlor by both conventional and germfree rats by the mercapturic acid pathway has been well characterized (Rafter et al., 1983; Bakke et al., 1980a; Larsen and Bakke, 1981; Pekas et al., 1979; Lamoureux and Davison, 1975). Swine also metabolize propachlor to the mercapturic acid conjugate (Bakke et al., 1980b; Larsen and Bakke, 1983).

Three major urinary metabolites were found in the 24-hour urine of rats given a single oral dose of carbonyl-labeled [^{14}C]-propachlor (Lamoureux and Davison, 1975). One of these metabolites was the mercapturic acid conjugate; the other two metabolites were not precursors of the propachlor mercapturic acid, but were probably oxidative or conjugative metabolites of propachlor (Lamoureux and Davison, 1975).

Pekas et al. (1979) examined the in vitro metabolism of propachlor by incubating rat small intestine with [^{14}C]-propachlor (2-chloro-N-isopropyl-[^{14}C]-acetanilide). The major metabolite, 2-(S-cysteinyl)-N-isopropylacetanilide cysteine, was formed by the replacement of a Cl with an

S-cysteinyl group. Pekas et al. (1979) proposed that the glutathione conjugate was the precursor of the cysteine conjugate, but the former metabolite was not verified in the in vitro rat intestine preparations. In vivo, the cysteine conjugate is further metabolized by an intestinal C-S lyase to two methylsulfones $[-S(O_2)CH_3]$ that have been identified as urinary metabolites of propachlor in rats (Bakke et al., 1976; Bakke and Price, 1978). Further evidence of the sulfur in the methylsulfonyl metabolites being derived from cysteine was reported by Larsen and Bakke (1978), in that administration of $[^{35}S]$ -cysteine conjugated propachlor resulted in $[^{35}S]$ -labeled methylsulfonyl urinary metabolites.

Larsen and Bakke (1981) examined the role of enterohepatic circulation in the formation of metabolites of ring-labeled $[^{14}C]$ -propachlor by rats. Using bile-cannulated conventional and germfree rats, and oral and i.v. administration of propachlor and some previously identified metabolites, Larsen and Bakke (1981) concluded that the metabolism of propachlor by conventional rats depends to a large degree upon the presence of the intestinal microflora. Larsen and Bakke (1981) also concluded that enterohepatic circulation of propachlor metabolites in conventional rats involves three or more cycles. Mercapturic acid conjugates of propachlor are excreted into the bile during the first cycle. The second cycle involves metabolism of the biliary mercapturic acid metabolites to resorbable metabolites (possibly 2-mercapto-N-isopropylacetanilide) by a microfloral (intestinal) C-S lyase. The third cycle includes metabolism of the resorbed metabolites to glucuronides, which are subsequently excreted with the bile. Microfloral β -glucuronidase activity participates in subsequent cycles.

Bakke et al. (1980b) examined the difference in metabolism of propachlor by swine receiving oral doses of either $[^{14}C]$ -propachlor (labeled location

not specified) or the labeled compound in conjunction with the antibiotic lincomycin. The extent of excretion of [^{14}C] within 72 hours after dosing was similar; swine given only [^{14}C]-propachlor excreted 81.9% of the administered [^{14}C] in the urine and 9.1% in the feces, while animals receiving both [^{14}C]-propachlor and lincomycin excreted 81% of the administered [^{14}C] in the urine and 8.9% in the feces. Metabolism, however, was dissimilar, in that swine receiving the antibiotic did not form sulfonyl-containing metabolites. The identified [^{14}C] urinary metabolites and their abundances are given in Table 4-1.

Larsen and Bakke (1983) incubated the [^{14}C]-labeled mercapturic acid pathway metabolites of propachlor (the glutathione, cysteine, N-acetylcysteine and S-oxide of the N-acetylcysteine conjugates) with mixed pig caecal microorganisms. Each of the conjugates was metabolized to 2-mercapto-N-isopropylacetanilide.

4.4. EXCRETION

As shown in Table 4-2, within 48 hours after oral dosing with [^{14}C]-propachlor (carbonyl- or ring-labeled), conventional rats excreted >60% of the administered [^{14}C] in the urine and <20% in the feces (Lamoureux and Davison, 1975; Rafter et al., 1983; Bakke et al., 1980a). Rats given [^{14}C]-propachlor (carbonyl-labeled) orally excreted 0.4% of the administered radioactivity as respiratory $^{14}\text{CO}_2$ within 48 hours after dosing (Lamoureux and Davison, 1975). Evidence of enterohepatic cycling of propachlor metabolites can be seen in the differing excretion patterns of germ-free and bile-cannulated rats, as compared with conventional rats; enterohepatic cycling of propachlor metabolites is mediated by the intestinal microflora (Section 4.3., Larsen and Bakke, 1981).

TABLE 4-1

Percentage of 72-Hour [^{14}C] Urinary Metabolites From
Swine Given Oral Doses of Either [^{14}C]-Propachlor or
Labeled Compound and Lincomycin*

Metabolite	Percentage of Administered [^{14}C]	
	[^{14}C]-Propachlor	[^{14}C]-Propachlor and Lincomycin
Cysteine conjugate of propachlor	12	16
Mercapturic acid conjugate of propachlor	31	48
Glucuronide conjugate of 2-methylsulfonyl-N-isopropylacetanilide	21	0
2-Methylsulfonyl acetic acid	8	0
Oxidized mercapturic acid conjugate	0	16

*Source: Bakke et al., 1980b

TABLE 4-2

Percent Recovery of [^{14}C] in the Urine and Feces of Rats and Swine Given [^{14}C]-Propachlor Orally

Species	Radioisotope	Time After Dose (hours)	Urinary Excretion*	Fecal Excretion*	Reference
Rats	carbonyl- ^{14}C	24 48	54-54 59.7-71	8-13 10.2-20.7	Lamoureux and Davison, 1975
Rats	ring- ^{14}C	48	61.4	NR	Rafter et al., 1983
Rats	NR	48	68	19	Bakke et al., 1980a
Germfree rats	ring- ^{14}C	48	48.8	34.1	Rafter et al., 1983
Germfree rats	NR	48	68.8	32.1	Bakke et al., 1980a
Rats (bile-cannulated)	ring- ^{14}C	8 24 48	17.4 51.2 85.9	NR 3.8 9.2	Larsen and Bakke, 1981
Swine	NR	72	81.9	9.1	Bakke et al., 1980b

*Expressed as percent of administered radioactivity

NR = Not reported

Swine given [^{14}C]-propachlor (label location not specified) excreted 81.9% of the administered [^{14}C] in the urine and 9.1% in the feces within 72 hours after dosing (Bakke et al., 1980b).

5. EFFECTS

5.1. CARCINOGENICITY

Pertinent data regarding the carcinogenicity of propachlor were not located in the available literature, and this compound is not scheduled for carcinogenicity testing by the National Toxicology Program (NTP, 1983).

5.2. MUTAGENICITY

Propachlor has been tested for genotoxicity in several test systems. These studies are summarized in Table 5-1.

Propachlor did not elicit a positive response in the reverse mutation assay with Salmonella typhimurium, either in the absence or presence of exogenous mammalian activation (Eisenbels et al., 1981; Njagi and Gopalan, 1980). Propachlor was negative in the mitotic gene conversion assay with Saccharomyces cerevisiae, strain D4 (Gentile et al., 1977). Conflicting results were obtained for propachlor in the sex-linked recessive lethal assay with Drosophila melanogaster (Murnik, 1976; Gopalan and Njagi, 1981), while negative results were obtained for the same test organism in the dominant lethal assay (Murnik, 1976). Propachlor significantly increased the frequency of aberrant metaphases in mouse bone marrow cells in vitro (Pilinskaya et al., 1980).

5.3. TERATOGENICITY

Oral administration of propachlor as a single dose during gestation or daily throughout gestation to rats and mice resulted in embryotoxic and teratogenic effects (Ivanova-Chemishanska et al., 1975; Mirkova, 1975). These Bulgarian studies were available only as abstracts; therefore, pertinent details, including dose levels and enumerated effects associated with these levels, were not provided for further evaluation of these studies.

TABLE 5-1
Genotoxicity Testing of Propachlor

Assay	Indicator Organism	Application	Concentration or Dose	Activation System	Response	Reference
Reverse mutation	<u>S. typhimurium</u> TA98 TA100 TA1535 TA1537 TA1538	spot test	10 μ l	$\pm$ S-9	-	Eisenbeis et al., 1981
Reverse mutation	<u>S. typhimurium</u> , strains NR	NR	NR	none	-	Njagi and Gopalan, 1980
Mitotic gene conversion	<u>S. cerevisiae</u> , strain D4	liquid incubation	1000 ppm	none	-	Gentile et al., 1977
Sex-linked recessive lethals	<u>D. melanogaster</u>	NR	NR	none	+	Murnik, 1976
Sex-linked recessive lethals	<u>D. melanogaster</u>	NR	NR	none	-	Gopalan and Njagi, 1981
Dominant lethals	<u>D. melanogaster</u>	NR	NR	none	-	Murnik, 1976
Aberrant metaphases	mouse bone marrow cells	cell culture	NR	none	+	Pillinskaya et al., 1980

NR - Not reported

5.4. OTHER REPRODUCTIVE EFFECTS

Testicular dystrophy and structural changes were reported in rats given propachlor daily for 4 months in conjunction with subjection to low frequency vibrations, while similar administration for 6 months resulted in increased protein content of the testes (Maleva and Shtereva, 1977; Zlateva and Maleva, 1978, 1979). These Bulgarian studies were available only as abstracts; therefore, pertinent details, including dose levels and enumerated effects associated with these levels, were not provided for further evaluation of these studies.

5.5. CHRONIC AND SUBCHRONIC TOXICITY

Three studies describing the effects of subchronic oral exposure to propachlor exist; two from the Russian literature and one from the Bulgarian literature (Strateva, 1976; Pan'shina, 1976; Maleva and Zlateva, 1982). These studies, however, were available only as abstracts; therefore, pertinent details, including dose levels and enumerated effects associated with these levels, were not provided for further evaluation of these three studies. Reported effects include enzyme induction and unspecified liver and kidney changes in rats given propachlor orally for 6 months (Strateva, 1976), unspecified changes in blood composition and in thyroid and liver function in rats and mice receiving propachlor by gastric gavage daily for 9-10 months (Pan'shina, 1976), and dose-related degenerative and necrotic effects on the renal tubules of rats receiving propachlor orally for 3 months (Maleva and Zlateva, 1982).

5.6. OTHER RELEVANT INFORMATION

The oral LD₅₀s for propachlor in rats, rabbits and mice have been reported to be 950, 392 and 290 mg/kg, respectively (Strateva, 1974, 1976).

The dermal LD₅₀ for propachlor in rabbits has been reported to be 380 mg/kg (NIOSH, 1983). Acute effects of oral exposure to propachlor in these three species of animals included excitation, tremor, respiratory insufficiency, dystrophic changes in the parenchymous organs, decreased level of blood hemoglobin and decreased levels of some liver, brain and kidney enzymes (Strateva, 1974; Strateva et al., 1974).

Dermal application of propachlor to rats at a level of 50-500 mg/kg, 6 days/week for 3 weeks, resulted in anemia and enzyme inhibition (blood, brain, liver) (Bainova et al., 1977). Application site effects included slight local alopecia and desquamation.

Propachlor is an eye irritant to rabbits (Lehotzky et al., 1979) and rats (Molnar and Molnar, 1976), a skin irritant to rabbits and mice (Lehotzky et al., 1979) and a nasal irritant to rats (Molnar and Molnar, 1976). Bainova and Ivanov (1975) reported that propachlor was a weak sensitizer to guinea pigs.

Schubert (1979) reported a case study in which occupational exposure to propachlor for 8 days resulted in erythematous-papulous contact eczema on the hands and forearms.

Propachlor inhibited proliferation of L1210 mouse leukemia cells (ID₅₀ $< 3 \times 10^{-7}$ M) and precursor (leucine, thymidine and uridine) uptake (Zilkah et al., 1981).

6. AQUATIC TOXICITY

Data on the toxicity of propachlor to aquatic organisms are very limited. Kenaga (1982) reported that the acute-chronic toxicity ratio for propachlor to fathead minnows, Pimephales promelas, was 4:1. This report, however, did not state the LC_{50} value (96-hour) and maximum acceptable toxicant concentration used in deriving this ratio. Dirlbek et al. (1974) reported that propachlor was toxic to brine shrimp, Artemia salina, at levels between 2 and 4 mg/l. Additional data on the toxicity of propachlor to aquatic plants or animals, data on its residues, and other relevant information were not located in the available literature.

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

The U.S. EPA has established tolerances for propachlor in or on agricultural commodities (Code of Federal Regulations, 1982; Federal Register, 1982). These tolerances are 0.02 ppm for meats, fats, eggs and milk; 0.1 ppm for corn, pumpkins and cottenseeds; 1.5-5 ppm for animal forage and 10 ppm for flax straw.

In the U.S.S.R., the maximum permissible oral dose of propachlor for humans (calculated) is 0.6 mg/day (Pan'shina, 1976), the maximum permissible concentration of propachlor for drinking water is 1 mg/l (Strateva, 1976) and the maximum permissible concentration of propachlor in the air of working environments is 0.5 mg/m³ (Pan'shina, 1977).

7.2. AQUATIC

Guidelines and standards for the protection of aquatic organisms from the toxic effects of propachlor were not located in the available literature. (See Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation.)

8. RISK ASSESSMENT

The lack of carcinogenicity tests for propachlor precludes the derivation of a cancer based quantitative risk assessment for that compound. The three subchronic studies with rats and mice (two from the Russian literature and one from the Bulgarian literature) are available only as abstracts. Therefore, details necessary to derive an ADI based on any of these studies were not provided.

Propachlor elicited a positive mutagenic response in the sex-linked recessive lethal assay with D. melanogaster (Murnik, 1976) and significantly increased the frequency of aberrant metaphases in mouse bone marrow cells in vitro (Pillinskaya et al., 1980), but was negative in several other genotoxicity assays (see Section 5.2.). Embryotoxic, teratogenic and reproductive effects in rats and mice following oral exposure to propachlor have been reported in several Bulgarian studies (Ivanova-Chemishanska et al., 1975; Mirkova, 1975; Maleva and Shtereva, 1977; Zlateva and Maleva, 1978, 1979). As with the subchronic studies mentioned above, however, these studies were available only as abstracts; therefore, pertinent details, including dose levels and enumerated effects associated with these levels, were not provided for further evaluation of these studies.

Statements concerning available literature in this document refer to published, quotable sources and are in no way meant to imply that confidential data, which this document could not address, are not in existence. These data, which are considered Confidential Business Information (CBI), are available in summary form as a CBI Appendix that can be accessed by individuals with appropriate clearance. Conclusions from the CBI Appendix regarding risk assessment, however, can be presented in this chapter.

The CBI Appendix to this document reviews other animal studies from which an ADI of 0.0133 mg/kg bw/day, or 0.931 mg/day for a 70 kg man, was derived. The ADI was based on a NOEL of 13.3 mg/kg bw/day in a 90-day feeding study in rats and an uncertainty factor of 1000 (10 to account for interspecies extrapolation, 10 for protection of the most sensitive humans within the population and 10 for the use of a subchronic NOEL for ADI derivation). The next highest dose in this study, 133.3 mg/kg bw/day, resulted in increased liver weight in the absence of histologic evidence of liver damage, decreased food consumption and body weight gain. Although these effects were not considered adverse, the dose of 133.3 mg/kg bw/day could not be used to calculate the ADI because decreased fetal viability was observed in rats receiving 100 mg/kg bw/day by gavage during gestation in another study.

9. REFERENCES

- Bainova, A. and I. Ivanov. 1975. Comparative evaluation of two methods for study of contact chemical sensitizers. *Dermatol. Venerol.* 14(3): 181-186. (Bul.) (CA 84: 87790p)
- Bainova, A., T. Burkova and A. Mikhailova. 1977. Determination of dermal toxicity of Ramrod. *Khig. Zdraveopaz.* 20(3): 234-240. (Bul.) (CA 87: 162459e)
- Baker, J.L. and J.M. Laflen. 1979. Runoff losses of surface-applied herbicides as affected by wheel tracks and incorporation. *J. Environ. Qual.* 8(4): 602-607.
- Bakke, J.E. and C.E. Price. 1978. Metabolism of 2-chloro-N-isopropylacetanilide (propachlor) in the rat. *J. Environ. Sci. Health, Part B.* 14: 427. (Cited in Pekas et al., 1979)
- Bakke, J.E., V.J. Fell and C.E. Price. 1976. Replacement of a chlorine with a methylsulfonyl group in the metabolism of propachlor (2-chloro-N-isopropylacetanilide). *Biomed. Mass. Spectrom.* 3: 226-229. (Cited in Pekas et al., 1979)
- Bakke, J.E., J. Gustafsson and B.E. Gustafsson. 1980a. Metabolism of propachlor by the germfree rat. *Science.* 210: 433-435.

Bakke, J.E., G.L. Larsen and P.W. Aschbacher. 1980b. The effect of oral lincomycin on the metabolism of the herbicide propachlor by the pig. J. Anim. Sci. 51: 256-257.

BCPC (British Crop Protection Council). 1977. Propachlor. In: Pesticide Manual, 5th ed., H. Martin and C.R. Worthing, Ed. BCPC Publications, Worcestershire, England. p. 438.

Beestman, G.B. and J.M. Deming. 1974. Dissipation of acetanilide herbicides from soils. Agronomy J. 66: 308-311.

Beestman, G.B. and J.M. Deming. 1976. Triallate mobility in soils. Weed Sci. 24(6): 541-544.

Carey, A.E., J.A. Gowen, H. Tai, W.G. Mitchell and G.B. Wiersma. 1978. Pesticide residue levels in soils and crops, 1971 - National Soils Monitoring Program (III). Pestic. Monit. J. 12: 117-136.

Carey, A.E., J.A. Gowen, H. Tai, W.G. Mitchell and G.B. Wiersma. 1979. Pesticide residue levels in soils and crops from 37 states, 1972 - National Soils Monitoring Program (IV). Pestic. Monit. J. 12(4): 209-229.

Code of Federal Regulations. 1982. 2-Chloro-N-isopropylacetanilide; tolerance for residues. 40 CFR 180.211.

Crockett, A.B., G.B. Wiersma, H. Tai, W.G. Mitchell, P.F. Sand and A.E. Carey. 1974. Pesticide residue levels in soils and crops, FY-70 - National Soils Monitoring Program (II). Pestic. Monit. J. 8: 69-97.

Cupitt, L.T. 1980. Fate of toxic and hazardous materials in the air environment. December. U.S. EPA, Research Triangle Park, NC. EPA 600/S3-80-084.

Dirlbek, J. K. Prazakova and H. Bendlova. 1974. Toxic effect of herbicides on small water crustaceans. Agrochimica. 14(6): 170-172. (Cze.)

Doyle, R.C., D.D. Kaufman and G.W. Burt. 1978. Effect of dairy manure and sewage sludge on ¹⁴C-pesticide degradation in soil. J. Agric. Food Chem. 26(4): 987-989.

Eichers, T.R, P.A. Andrienas and T.W. Anderson. 1978. Farmers' Use of Pesticides in 1976. U.S. Department of Agriculture Economics, Statistics and Cooperative Service. Agric. Economic Rep. No. 418.

Eisenbeis, S.J., D.L. Lynch and A.E. Hampel. 1981. Ames mutagen assay tested against herbicides and herbicide combinations. Soil Sci. 131: 44-47.

Federal Register. 1982. Tolerances for pesticide chemicals in or on raw agricultural commodities; 2-chloro-N-isopropylacetanilide. Federal Register. 47(116): 25958-25959.

Frank, R., G.J. Strons, M.J. Paik and M. Valk. 1977. Fate of propachlor applied to onions and organic soils. *Can. J. Plant Sci.* 57(2): 473-477.

Gentile, J.M., E.D. Wagner and M.J. Plewa. 1977. The detection of weak recombinogenic activities in the herbicides alachlor and propachlor using a plant-activation bioassay. *Mutat. Res.* 48(1): 113-115.

Gopalan, H.N.B. and G.D.E. Njagi. 1981. Mutagenicity testing of pesticides. *Genetics.* 97(1): S44.

Helling, C.S. and J. Dragun. 1981. Soil leaching tests for toxic organic chemicals. In: Test Protocols for Environmental Fate and Movement of Toxicants. Proc. Symp. Assoc. Official Anal. Chem., 94th Ann. Meet., Washington, DC. p. 43-88.

Ivanova-Chemishanska, L. T. Petrova-Vergieva and E. Mirkova. 1975. Embryo-toxic and teratogenic action of some pesticides. *Eksp. Med. Morfol.* 14(1): 29-33. (Bul.) (CA 83: 158773c)

Kaufman, D.D. and J. Blake. 1972. Microbial degradation of several acetamide, acylanilide, carbamate, toluidine and urea pesticides. *Soil Biol. Biochem.* 5(3): 297-308.

Kaufman, D.D. and D.F. Edwards. 1983. Pesticide/microbe interaction effects on persistence of pesticides in soil. *Pestic. Chem.* 4: 177-182.

Kaufman, D.D., J.R. Plimmer and J. Iwan. 1971. Microbial degradation of propachlor. Am. Chem. Soc. Abstr. 162nd Meet., Washington, DC. A-21. (Cited in Kaufman and Blake, 1972)

Kenaga, E.E. 1980. Predicted bioconcentration factors and soil sorption coefficients of pesticides and other chemicals. Ecotox. Environ. Safety. 4: 26-38.

Kenaga, E.E. 1982. Predictability of chronic toxicity from acute toxicity of chemicals in fish and aquatic invertebrates. Environ. Toxicol. Chem. 1(4): 347-358.

Lamoureux, G.L. and K.L. Davison. 1975. Mercapturic acid formation in the metabolism of propachlor, CDAA and fluorodifen in the rat. Pestic. Biochem. Physiol. 5(6): 497-506.

Larsen, G.L. and J.E. Bakke. 1978. Studies on the origin of the methylsulfonyl-containing metabolites from propachlor. J. Environ. Sci. Health, Part B. 5: 495. (Cited in Pekas et al., 1979)

Larsen, G.L. and J.E. Bakke. 1981. Enterohepatic circulation in formation of propachlor (2-chloro-N-isopropylacetanilide) metabolites in the rat. Xenobiotica. 11(7): 473-480.

Larsen, G.L. and J.E. Blake. 1983. Metabolism of mercapturic acid-pathway metabolites of 2-chloro-N-isopropylacetanilide (propachlor) by gastrointestinal bacteria. Xenobiotica. 13(2): 115-126.

Lee, J.K., R.D. Minard and J.M. Bollag. 1982. Microbial metabolism of propachlor (2-chloro-N-isopropylacetanilide) in soil suspension. Hanguk Nonghwa Hakhoe Chi. 25(1): 44-54. (CA 97: 123592e)

Lehotzky, K., J. Szeberenyi and E. Tatrai. 1979. Local and systemic toxic effects of the herbicide propachlor (Satecid 65 WP) in experimental animals. Egeszsegstudomany. 23(1): 89-96. (Hun.) (PESTAB 79: 2433)

Maleva, E. and M. Shtereva. 1977. Biochemical study of changes in the gonads of male white rats under the combined effect of low-frequency vibration and Ramrod poisoning. I. Changes in total protein content. Nats. Nauchna Ses. Khim. Med. Profil. (Dokl.) 2: 306-313. (Bul.) (CA 89: 1376b)

Maleva, E. and M. Zlateva. 1982. Histomorphological changes in kidneys of experimental animals under the combined effect of low-frequency vibration and intoxication with Ramrod herbicide. Khig. Zdraveopaz. 25(3): 244-249. (Bul.) (CA 97: 139916z)

Mirkova, E. 1975. Effect of the herbicide Ramrod on the embryogenesis of white rats. Probl. Khig. 1: 57-60. (Bul.) (CA 87: 16813z)

Molnar, J. and A.M. Molnar. 1976. Quantitative evaluation of acute inflammatory activity of ocular irritants on the eyelid in rats. Egeszsegstudomany. 20(2): 156-160. (Hun.) (CA 86: 26680x)

Murnik, M.R. 1976. Mutagenicity of widely used herbicides. Genetics. 83: S54.

Nesterova, O.A., V.V. Popova and O.P. Kolesnikova. 1980. Accumulation of semeron, mesoramil and ramrod in the soil and cabbages during long-term use. Sib. Vestn. S-kh. Nauki. 10(4): 19-21. (Rus.) (CA 94: 059666v)

NIOSH (National Institute of Occupational Safety and Health. 1983. RTECS (Registry of Toxic Effects of Chemical Substances). November: online.

Njagi, G.D.E. and H.N.B. Gopalan. 1980. Mutagenicity testing of some selected food preservatives, herbicides and insecticides: 2. Ames test. Bangladesh J. Bot. 9(2): 141-146. (HEEP 81: 9425)

NTP (National Toxicology Program). 1983. Management Status Report, dated December 5.

Ouellette, R.P. and J.A. King. 1977. Chemical Week Pesticides Register. McGraw-Hill Book Co., New York. p. 265.

Pan'shina, T.N. 1976. Hygienic aspects of the use of certain herbicides in agriculture and toxicology. Gig. San't. 7: 38-41. (Rus.) (C 85: 187425n)

Pan'shina, T.N. 1977. Establishment of maximum permissible concentrations and approximately safe levels of herbicides of halide substituted carboxylic acids anilides in the air of a working area. Gig. Tr. Prof. Zabol. 12: 3033. (Rus.) (CA 88: 125762y)

Pekas, J.C., G.L. Larsen and V.J. Feil. 1979. Propachlor detoxication in the small intestine: Cysteine conjugation. J. Toxicol. Environ. Health. 5(4): 653-662. (CA 91(17): 135194r)

Pilinskaya, M.A., A.I. Kurinnyi, T.S. L'vova and I.V. German. 1980. Primary evaluation of cytogenetic activity and potential mutagenic hazard of 22 pesticides. Tsitol. Genet. 14(6): 41-47. (Rus.) (CA 94: 97528e)

Rafter, J.J., J.A. Gustafsson, J.E. Bakke, G.L. Larsen, K.E. Norin and B.E. Gustafsson. 1983. Studies on the re-establishment of the intestinal microflora in germ-free rats with special reference to the metabolism of N-isopropyl-alpha-chloroacetanilide (propachlor). Xenobiotica. 13(3): 171-178.

Rankov, V. and B. Velez. 1976. Effect of temperature on the interaction between the metribuzin and propachlor herbicides and soil microorganisms. Pochvozn. Agrokhim. 11(5): 100-105. (Bul.) (CA 86: 184455g)

Rao, P.S.C. and J.M. Davidson. 1982. Retention and transformation of selected pesticides and phosphorus in soil-water systems: A critical review. U.S. EPA, Athens, GA. EPA 600/S3-82-060.

Ritter, W.F., H.P. Johnson, W.G. Lovely and M. Molnau. 1974. Atrazine, propachlor and diazinon residues on small agricultural watersheds - runoff losses, persistence and movement. Environ. Sci. Technol. 8(1): 38-42.

Schubert, H. 1979. Allergic contact dermatitis due to propachlor. Dermatol. Monatsschr. 165(7): 495-498. (Ger.) (PESTAB 80: 115)

Shirko, T.S. and A.P. Kharitonova. 1981. Herbicide residues in the soil and in onion plants. Khim. Sel'sk. Khoz. 6: 54-56. (CA 95: 75344k)

SRI (Stanford Research Institute). 1976. Herbicides. In: Chemical Economics Handbook. SRI, Menlo Park, CA. p. 573.7008 E-F.

SRI (Stanford Research Institute). 1983. 1983 Directory of Chemical Producers: United States of America. SRI International, Menlo Park, CA. p. 786.

Strateva, A. 1974. Amide preparations with herbicidal effect. Acute oral poisoning of propachlor. Eksp. Med. Morfol. 13(2): 123-129. (Bul.) (CA 83: 54216g)

Strateva, A. 1976. Experimental substantiation of the maximum permissible concentrations of propachlor (Ramrod) in water. Gig. Sanit. 4: 85-87. (Rus.) (CA 85: 989j)

Strateva, A., A. Velizarov and A. Georgiev. 1974. Morphological and enzymohistochemical studies on some internal organs of experimental animals during the influence of Ramrod under acute experimental conditions. Khig. Zdraveopaz. 17(3): 283-287. (Bul.) (CA 82: 93927p)

Tanaka, F.S., R.G. Wien and E.R. Mansager. 1981. Survey for surfactant effects on the photodegradation of herbicides in aqueous media. J. Agric. Food Chem. 29: 227-230.

U.S. Department of Agriculture. 1983. Inputs Outlook and Situation. Economic Research Service. IOS-2. October.

USITC (United States International Trade Commission). 1983. Synthetic organic chemicals, U.S. Production and Sales, 1982. USITC Publ. 1422. U.S. International Trade Commission, Washington, DC. p. 228.

Vasil'ev, N.V. 1982. Residual quantity of Ramrod in soil and fodder rutabagas. Khim. Sel'sk. Khoz. 6: 51-53. (Rus.) (CA 97: 067697d)

Wauchope, R.D. and R.A. Leonard. 1980. Maximum pesticide concentrations in agricultural runoff: A semiempirical prediction formula. J. Environ. Qual. 9(4): 665-672.

Weber, J.B. and J.A. Best. 1972. Activity and movement of 13 soil-applied herbicides as influenced by soil reaction. Proc. S. Weed Sci. Soc. 25: 403-413. (CA 77: 110456a)

WSSA (Weed Science Society of America). 1979. Propachlor. In: Herbicide Handbook of the Weed Science Society of America, 4th ed. WSSA, Champaign, IL. p. 372-375.

Yu, C.C., G.M. Booth, D.J. Hansen and J.R. Larsen. 1975. Fate of alachlor and propachlor in a model ecosystem. J. Agric. Food Chem. 23(5): 877-879.

Zhukova, P.S. and T.S. Shirko. 1979. Herbicide residues in soil and vegetables. Khim. Sel'sk. Khoz. 17(6): 46-50. (Rus.) (CA 91: 085051u)

Zilkah, S., M.E. Osband and R.P. McCaffrey. 1981. Characterization of the inhibitory effects of the phytotoxic agent propachlor (alpha-chloro-N-iso-propylacetanilide), on L1210 cell proliferation. Cancer Lett. 13(3): 241-248.

Zimdahl, R.L. and S.K. Clark. 1982. Degradation of three acetanilide herbicides in soil. Weed Sci. 30(5): 545-548.

Zlateva, M. and E. Maleva. 1978. Late changes in the gonads of male white rats upon combined treatment with low frequency vibrations and Ramrod intoxication. Scr. Sci. Med. 15(1): 85-91. (CA 90: 162963b)

Zlateva, M. and E. Maleva. 1979. Disturbances in the processes of division and differentiation of spermatopoietic epithelium in rats during chronic intoxication with ramrod. Eksp. Med. Morfol. 18(1): 35-40. (Bul.) (CA 91: 103285e)

APPENDIX
LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of the following:

CA SEARCH (Files 308, 309, 310, 311, 320)
TOXLINE
MEDLINE
RTECS
SCI SEARCH
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE

These searches were conducted in November, 1983. In addition, hand searches were made of Chemical Abstracts (Collective Indices 6 and 7th), and the following secondary sources were reviewed:

ACGIH (American Conference of Governmental Industrial Hygienists). 1980. Documentation of the Threshold Limit Values, 4th ed. (Includes Supplemental Documentation, 1981, 1982, 1983). Cincinnati, OH. 486 p.

ACGIH (American Conference of Governmental Industrial Hygienists). 1983. TLVs: Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1983-84. Cincinnati, OH. 94 p.

BCPC (British Crop Protection Council). 1977. Pesticide Manual, 5th ed., H. Martin and C.R. Worthing, Ed. British Crop Protection Council. 593 p.

Clayton, G.D. and F.E. Clayton, Ed. 1981. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2A. John Wiley and Sons, NY. 2878 p.

Clayton, G.D. and F.E. Clayton, Ed. 1981. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2B. John Wiley and Sons, NY. 2879-3816 p.

Clayton, G.D. and F.E. Clayton, Ed. 1982. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2C. John Wiley and Sons, NY. 3817-5112 p.

Grayson, M. and D. Eckroth, Ed. 1978-83. Kirk-Othmer Encyclopedia of Chemical Technology, 3rd ed. John Wiley and Sons, NY. 23 Volumes.

Hamilton, A. and H.L. Hardy. 1974. Industrial Toxicology, 3rd ed. Publishing Sciences Group, Inc., MA. 575 p.

ITII (International Technical Information Institute). 1982. Toxic and Hazardous Industrial Chemicals Safety Manual for Handling and Disposal with Toxicity and Hazard Data. ITII, Tokyo, Japan. 700 p.

NTP (National Toxicology Program). 1983. Carcinogenesis Testing Program. Chemicals on Standard Protocol. Management Status.

Ouellette, R.P. and J.A. King. 1977. Chemical Week Pesticide Register. McGraw-Hill Book Co., NY.

Sax, I.N. 1979. Dangerous Properties of Industrial Materials, 5th ed. Van Nostrand Reinhold Co., NY.

SRI (Stanford Research Institute). 1983. Directory of Chemical Producers. Menlo Park, CA.

U.S. EPA. 1982. Chemical Activities Status Report, 3rd ed. (EPA CASR). Offices of Pesticides and Toxic Substances, Washington, DC. EPA 560/TIIS-82-002b.

U.S. EPA. 1983. Status Report on Rebuttable Presumption Against Registration (RPAR) or Special Review Process. Registration Standards and the Data Call In Programs. Office of Pesticide Programs, Washington, DC.

U.S. EPA. 1983. CHIB Existing Chemical Assessment Tracking System. Name and CAS Number Ordered Indexes. Office of Toxic Substances, Washington, DC.

USITC (United States International Trade Commission). 1983. Synthetic Organic Chemicals. U.S. Production and Sales, 1982. Washington, DC. USITC Publ. 1422.

Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals, 2nd ed. Van Nostrand Reinhold Co., NY.